

What is claimed is:

1. An array waveguide grating comprising:

a predetermined substrate;

a first and a second channel waveguide for light wave transfer on the substrate;

a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate;

a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel waveguide array via a waveguide part having a first shape on the substrate; and

a second slab waveguide for connecting one end of the second channel waveguides and the other end of the channel waveguide array via a waveguide part having a second shape on the substrate; wherein:

at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide is flaring in an exponential function shape toward the channel waveguide array.

2. An array waveguide grating comprising:

a predetermined substrate;

a first and a second channel waveguide for light wave transfer on the substrate;

a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate;

a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel waveguide array via a waveguide part having a first shape on the substrate; and

a second slab waveguide for connecting one end of the second channel waveguides and the other end of the channel waveguide array via a waveguide part having a second shape on the substrate; wherein:

at least a part of at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide is flaring in an exponential function shape toward the channel waveguide array.

3. The array waveguide grating according to claim 1 or 2, wherein the shape $W(X)$ flaring in the exponential function shape is represented as

$$W(X) = (W_p - W_c) * (1 - \exp(-a * X)) + W_c$$

where X represents the light wave progress direction, W_p is the width of the end of the shape connected to the slab waveguide, W_c is the spread of the waveguide part in directions perpendicular to the light wave progress direction X , and a represents a parameter (i.e., shape

variable) giving the exponential function shape.

4. The array waveguide grating according to claim 3, wherein the shape variable a giving the exponential function shape is unity or below.

5. The array waveguide grating according to claim 3, wherein both of the first and second shape waveguide parts have a shape part flaring from in an exponential function shape from the side of the channel waveguides toward the channel waveguide array and are different in the value of the shape variable a from each other.

6. The array waveguide grating according to claim 3, wherein at least either the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide has a shape part flaring in an exponential function shape toward the channel waveguide array, and the value of the shape variable a is set independently to a value corresponding to a corresponding channel waveguide.

7. The array waveguide grating according to claim 2, wherein parts of the first and second shape waveguide parts which do not have any shape part flaring in the exponential function shape have a taper shape.

8. The array waveguide grating according to claim 2, wherein parts of the first and second shape waveguide parts which do not have any shape part flaring in the exponential function shape have a second degree function shape.

9. The array waveguide grating according to claim 2, wherein parts of the first and second shape waveguide parts which do not have any shape part flaring in the exponential function shape have both a taper shape and a second degree function shape.

10. The array waveguide grating according to claim 2, wherein the other shapes in the case of a part containing a shape part flaring in the exponential function shape consist of a taper shape part.

11. The array waveguide grating according to claim 2, wherein the other shapes in the case of a part containing a shape part flaring in the exponential function shape consist of a second degree function shape part.

12. The array waveguide grating according to claim 2, wherein the other shapes in the case of a part containing a shape part flaring in the exponential function shape consist of a taper shape part and a second degree function shape part.

13. An array waveguide grating comprising:
a predetermined substrate;
a first and a second channel waveguide for light wave transfer on the substrate;
a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate;
a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel waveguide array via a waveguide part having a first shape on the substrate; and
a second slab waveguide for connecting one end of the second channel waveguides and the other end of the channel waveguide array via a waveguide part having a second shape on the substrate; wherein:
at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides with respect to the second slab waveguide has a shape part flaring in an exponential function shape represented by a function of a degree higher than the second degree toward the channel waveguide array.

14. An array waveguide grating comprising:
first and second channel waveguides for light wave transfer;
a channel waveguide array having a plurality of

component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides;

a first slab waveguide disposed between the first channel waveguides and one end of the channel waveguide array; and

a second slab waveguide disposed between the second channel waveguides and the other end of the channel waveguide array; wherein:

at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide has an open end with an opening width greater than the waveguide width of the first or second channel waveguides; and

the shape directed from the stem part of the open part toward the open end is found on the inner side of rectangular shape of the opening width and on the outer side of a second degree curve connecting the stem part and the open end.

15. The array waveguide grating according to claim 13, wherein the flaring shape part represented by the function of a degree higher than the second degree has such a convex shape that when frequency multiplexed Gaussian waveform light waves pass through their waveguides, their characteristics line in a range between boundary ranges of characteristics with respect to the transmission width and

the cross-talk when they pass through the rectangular waveguides and second degree function shape waveguides.

16. An array waveguide grating module comprising:
an array waveguide grating including a predetermined substrate, a first and a second channel waveguide for light wave transfer on the substrate, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate, a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel waveguide array via a waveguide part having a first shape on the substrate, and a second slab waveguide for connecting one end of the second channel waveguides and the other end of the channel waveguide array via a waveguide part having a second shape on the substrate, wherein at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide is flaring in an exponential function shape toward the channel waveguide array; and

an optical fiber having one end optically connected to at least part of the first or second channel waveguides of the array waveguide grating.

17. An array waveguide grating module comprising:

an array waveguide grating including a predetermined substrate, a first and a second channel waveguide for light wave transfer on the substrate, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate, a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel waveguide array via a waveguide part having a first shape on the substrate, and a second slab waveguide for connecting one end of the second channel waveguides and the other end of the channel waveguide array via a waveguide part having a second shape on the substrate; wherein at least a part of at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide is flaring in an exponential function shape toward the channel waveguide array; and

an optical fiber having one end optically connected to at least part of the first or second channel waveguides of the array waveguide grating.

18. An array waveguide grating module comprising:
an array waveguide grating including first and second channel waveguides for light wave transfer, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with

a predetermined difference between adjacent ones of the waveguides, a first slab waveguide disposed between the first channel waveguides and one end of the channel waveguide array and a second slab waveguide disposed between the second channel waveguides and the other end of the channel waveguide array, wherein at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide has an open end with an opening width greater than the waveguide width of the first or second channel waveguides, and the shape directed from the stem part of the open part toward the open end is found on the inner side of rectangular shape of the opening width and on the outer side of a second degree curve connecting the stem part and the open end; and

an optical fiber having one end optically connected to at least part of the first or second channel waveguides of the array waveguide grating.

19. The array waveguide grating module according to claim 16 or 17, wherein the shape $W(X)$ flaring in the exponential function shape is represented as

$$W(X) = (W_p - W_c) * (1 - \exp(-a * X)) + W_c$$

where X represents the light wave progress direction, W_p is the width of the end of the shape connected to the slab waveguide, W_c is the spread of the waveguide part in directions perpendicular to the light wave progress

direction X , and a represents a parameter (i.e., shape variable) giving the exponential function shape.

20. The array waveguide grating module according to claim 19, wherein the shape variable a giving the exponential function shape is unity or below.

21. The array waveguide grating module according to claim 19, wherein both of the first and second shape waveguide parts have a shape part flaring from in an exponential function shape from the side of the channel waveguides toward the channel waveguide array and are different in the value of the shape variable a from each other.

22. The array waveguide grating module according to claim 19, wherein at least either the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide has a shape part flaring in an exponential function shape toward the channel waveguide array, and the value of the shape variable a is set independently to a value corresponding to a corresponding channel waveguide.

23. The array waveguide grating module according to claim 16 or 17, wherein parts of the first and second shape waveguide parts which do not have any shape part flaring

in the exponential function shape have a taper shape.

24. The array waveguide grating module according to claim 16 or 17, wherein parts of the first and second shape waveguide parts which do not have any shape part flaring in the exponential function shape have a second degree function shape.

25. The array waveguide grating module according to claim 16 or 17, wherein parts of the first and second shape waveguide parts which do not have any shape part flaring in the exponential function shape have both a taper shape and a second degree function shape.

26. The array waveguide grating module according to claim 17, wherein the other shapes in the case of a part containing a shape part flaring in the exponential function shape consist of a taper shape part.

27. The array waveguide grating module according to claim 17, wherein the other shapes in the case of a part containing a shape part flaring in the exponential function shape consist of a second degree function shape part.

28. The array waveguide grating module according to claim 17, wherein the other shapes in the case of a part containing a shape part flaring in the exponential

function shape consist of a taper shape part and a second degree function shape part.

29. An array waveguide grating module comprising:
an array waveguide grating including a predetermined substrate, a first and a second channel waveguide for light wave transfer on the substrate, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate, a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel waveguide array via a waveguide part having a first shape on the substrate, and a second slab waveguide for connecting one end of the second channel waveguides and the other end of the channel waveguide array via a waveguide part having a second shape on the substrate, wherein at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides with respect to the second slab waveguide has a shape part flaring in an exponential function shape represented by a function of a degree higher than the second degree toward the channel waveguide array; and
an optical fiber having one end optically connected to at least part of the first or second channel waveguides of the array waveguide grating.

30. The array waveguide grating module according to claim 29, wherein the flaring shape part represented by the function of a degree higher than the second degree has such a convex shape that when frequency multiplexed Gaussian waveform light waves pass through their waveguides, their characteristics line in a range between boundary ranges of characteristics with respect to the transmission width and the cross-talk when they pass through the rectangular waveguides and second degree function shape waveguides.

31. An optical communication system comprising:
an optical transmission means for sending out light signals of different wavelengths as parallel signals;
a multiplexer constituted by an array waveguide grating for wavelength multiplexing/demultiplexing each of the different wavelength light signals sent out from the optical transmission means;
an optical transmission line, to which the wavelength divided and multiplexed light signals outputted from the multiplexer are sent;
a node provided in the optical transmission line and having an array waveguide grating;
a demultiplexer constituted by an array waveguide array for receiving input light signal set along the optical transmission line via the node; and
an optical receiving means for receiving the demultiplexed different wavelength light signals from the

demultiplexer;

wherein the demultiplexer includes a predetermined substrate, a first and a second channel waveguide for light wave transfer on the substrate, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate, a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel waveguide array via a waveguide part having a first shape on the substrate, and a second slab waveguide for connecting one end of the second channel waveguides and the other end of the channel waveguide array via a waveguide part having a second shape on the substrate, and at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide is flaring in an exponential function shape toward the channel waveguide array.

32. An optical communication system comprising:

an optical transmission means for sending out light signals of different wavelengths as parallel signals;

a multiplexer constituted by an array waveguide grating for wavelength multiplexing/demultiplexing each of the different wavelength light signals sent out from the optical transmission means;

an optical transmission line, to which the

wavelength divided and multiplexed light signals
outputted from the multiplexer are sent;

a node provided in the optical transmission line and
having an array waveguide grating;

a demultiplexer constituted by an array waveguide
array for receiving input light signal set along the
optical transmission line via the node; and

an optical receiving means for receiving the
demultiplexed different wavelength light signals from the
demultiplexer;

wherein the demultiplexer includes a predetermined
substrate, a first and a second channel waveguide for
light wave transfer on the substrate, a channel waveguide
array having a plurality of component waveguides having
lengths progressively increasing with a predetermined
difference between adjacent ones of the waveguides on the
substrate, a first slab waveguide for connecting the ends
of the first channel waveguides and one end of the channel
waveguide array via a waveguide part having a first shape
on the substrate, and a second slab waveguide for
connecting one end of the second channel waveguides and
the other end of the channel waveguide array via a
waveguide part having a second shape on the substrate, and
at least a part of at least the open part of each of the
first channel waveguides on the side of the first slab
waveguide or the open part of each of the second channel
waveguides on the side of the second slab waveguide is
flaring in an exponential function shape toward the

channel waveguide array.

33. An optical communication system comprising:
an optical transmission means for sending out light signals of different wavelengths as parallel signals;
a multiplexer constituted by an array waveguide grating for wavelength multiplexing/demultiplexing each of the different wavelength light signals sent out from the optical transmission means;

an optical transmission line, to which the wavelength divided and multiplexed light signals outputted from the multiplexer are sent;

a node provided in the optical transmission line and having an array waveguide grating;

a demultiplexer constituted by an array waveguide array for receiving input light signal set along the optical transmission line via the node; and

an optical receiving means for receiving the demultiplexed different wavelength light signals from the demultiplexer;

wherein the demultiplexer includes a predetermined substrate, a first and a second channel waveguide for light wave transfer on the substrate, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate, a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel

waveguide array via a waveguide part having a first shape on the substrate, and a second slab waveguide for connecting one end of the second channel waveguides and the other end of the channel waveguide array via a waveguide part having a second shape on the substrate, and includes at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides with respect to the second slab waveguide has a shape part flaring in an exponential function shape represented by a function of a degree higher than the second degree toward the channel waveguide array.

34. An optical communication system comprising:
an optical transmission means for sending out light signals of different wavelengths as parallel signals;
a multiplexer constituted by an array waveguide grating for wavelength multiplexing/demultiplexing each of the different wavelength light signals sent out from the optical transmission means;
an optical transmission line, to which the wavelength divided and multiplexed light signals outputted from the multiplexer are sent;
a node provided in the optical transmission line and having an array waveguide grating;
a demultiplexer constituted by an array waveguide array for receiving input light signal set along the optical transmission line via the node; and

an optical receiving means for receiving the demultiplexed different wavelength light signals from the demultiplexer;

wherein the demultiplexer including first and second channel waveguides for light wave transfer, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides, a first slab waveguide disposed between the first channel waveguides and one end of the channel waveguide array, and a second slab waveguide disposed between the second channel waveguides and the other end of the channel waveguide array, and at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide has an open end with an opening width greater than the waveguide width of the first or second channel waveguides, and the shape directed from the stem part of the open part toward the open end is found on the inner side of rectangular shape of the opening width and on the outer side of a second degree curve connecting the stem part and the open end.

35. The array waveguide grating according to claim 33, wherein the flaring shape part represented by the function of a degree higher than the second degree has such a convex shape that when frequency multiplexed Gaussian

waveform light waves pass through their waveguides, their characteristics line in a range between boundary ranges of characteristics with respect to the transmission width and the cross-talk when they pass through the rectangular waveguides and second degree function shape waveguides.

36. An optical communication system comprising a plurality of nodes connected by transfer lines into a loop form, wavelength multiplexed and demultiplexed light signals being transferred along the loop form transfer line, the nodes each including a first array waveguide grating for demultiplexing the multiplexed light signal into light signals of different wavelengths and a second array waveguide grating for multiplexing the demultiplexed light signals of the different wavelengths, wherein the first array waveguide grating includes a predetermined substrate, a first and a second channel waveguide for light wave transfer on the substrate, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate, a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel waveguide array via a waveguide part having a first shape on the substrate, and a second slab waveguide for connecting one end of the second channel waveguides and the other end of the channel waveguide array via a waveguide part having a second shape on the substrate,

and at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide is flaring in an exponential function shape toward the channel waveguide array.

37. An optical communication system comprising a plurality of nodes connected by transfer lines into a loop form, wavelength multiplexed and demultiplexed light signals being transferred along the loop form transfer line, the nodes each including a first array waveguide grating for demultiplexing the multiplexed light signal into light signals of different wavelengths and a second array waveguide grating for multiplexing the demultiplexed light signals of the different wavelengths, wherein the first array waveguide grating includes a predetermined substrate, a first and a second channel waveguide for light wave transfer on the substrate, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate, a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel waveguide array via a waveguide part having a first shape on the substrate, a second slab waveguide for connecting one end of the second channel waveguides and the other end of the channel waveguide array

via a waveguide part having a second shape on the substrate, and at least a part of at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide is flaring in an exponential function shape toward the channel waveguide array.

38. An optical communication system comprising a plurality of nodes connected by transfer lines into a loop form, wavelength multiplexed and demultiplexed light signals being transferred along the loop form transfer line, the nodes each including a first array waveguide grating for demultiplexing the multiplexed light signal into light signals of different wavelengths and a second array waveguide grating for multiplexing the demultiplexed light signals of the different wavelengths, wherein the first array waveguide grating includes a predetermined substrate, a first and a second channel waveguide for light wave transfer on the substrate, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides on the substrate, a first slab waveguide for connecting the ends of the first channel waveguides and one end of the channel waveguide array via a waveguide part having a first shape on the substrate, a second slab waveguide for connecting one end of the second channel

waveguides and the other end of the channel waveguide array via a waveguide part having a second shape on the substrate, and at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides with respect to the second slab waveguide has a shape part flaring in an exponential function shape represented by a function of a degree higher than the second degree toward the channel waveguide array.

39. An optical communication system comprising a plurality of nodes connected by transfer lines into a loop form, wavelength multiplexed and demultiplexed light signals being transferred along the loop form transfer line, the nodes each including a first array waveguide grating for demultiplexing the multiplexed light signal into light signals of different wavelengths and a second array waveguide grating for multiplexing the demultiplexed light signals of the different wavelengths, wherein the first array waveguide grating includes first and second channel waveguides for light wave transfer, a channel waveguide array having a plurality of component waveguides having lengths progressively increasing with a predetermined difference between adjacent ones of the waveguides, a first slab waveguide disposed between the first channel waveguides and one end of the channel waveguide array, a second slab waveguide disposed between the second channel waveguides and the other end of the

channel waveguide array, at least the open part of each of the first channel waveguides on the side of the first slab waveguide or the open part of each of the second channel waveguides on the side of the second slab waveguide has an open end with an opening width greater than the waveguide width of the first or second channel waveguides, and the shape directed from the stem part of the open part toward the open end is found on the inner side of rectangular shape of the opening width and on the outer side of a second degree curve connecting the stem part and the open end.

40. The optical communication system according to claim 38, wherein the flaring shape part represented by the function of a degree higher than the second degree has such a convex shape that when frequency multiplexed Gaussian waveform light waves pass through their waveguides, their characteristics line in a range between boundary ranges of characteristics with respect to the transmission width and the cross-talk when they pass through the rectangular waveguides and second degree function shape waveguides.